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(54) HIGH STRENGTH HOT DIP GALVANIZED STEEL SHEET HAVING EXCELLENT PLATING ADHESION ON HIGH WORKING AND EXCELLENT DUCTILITY, AND PRODUCTION METHOD THEREFOR

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a high strength hot dip galvanized steel sheet which has improved unplating and plating adhesion on high working, and has excellent ductility, and to provide a production method therefor.

SOLUTION: The high strength hot dip galvanized steel sheet has a plated layer having a composition containing 0.001 to 0.5% Al and 0.001 to 2% Mn, and containing, at need, 5 to 20% Fe, and the balance Zn with inevitable impurities. The Si content in the steel: X(%), the Mn content in the steel: Y(%), the Al content in the steel: Z(%), the Al content in the plated layer: A(%) and the Mn content in the plated layer: B(%) satisfy the following inequality (1),

and the microstructure of the steel sheet consists of, by volume fraction, 70 to 97% ferrite having a mean grain diameter of $\leq 20 \mu\text{m}$ and 3 to 30% austenite and/or martensite having a mean grain diameter of $\leq 10 \mu\text{m}$. $3-(X+Y/10+Z/3)-12.5 \times (A-B) \geq 0 \dots (1)$.

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CLAIMS

[Claim(s)]

[Claim 1] At mass %, it is C. : On the front face of the steel plate which contains 0.0001 - 0.3%, Si:0.01-2.5%, Mn:0.01-3%, and aluminum:0.001-4%, and consists of the remainder Fe and an unescapable impurity, by mass % aluminum:0.001-0.5% and Mn:0.001-2% are contained. It is the hot-dip zinc-coated carbon steel sheet which has the plating layer which the remainder becomes from Zn and an unescapable impurity. Si content of steel : Mn content:Y (mass %) of X (mass %) and steel, aluminum content:Z of steel (mass %), aluminum content of a plating layer : A (mass %) and Mn content:B (mass %) of a plating layer The following (I) type is filled and the microstructure of a steel plate is [the mean particle diameter of *Perilla frutescens* (L.) Britton var. *crispa* (Thunb.) Decne.] 20 micrometers or less as the main phase about 70 - 97% of ferrite in a volume fraction. The high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing which consists of 3 - 30% of austenite, and/or martensite with a volume fraction as the 2nd phase, and is characterized by the mean particle diameter of the 2nd phase being 10 micrometers or less, and ductility.

3-(10+Z [X+Y/]/3)-12.5x(A-B) >=0 ... (I)

[Claim 2] The high intensity melting Zn plating steel plate which was furthermore excellent in the plating adhesion at the time of high processing according to claim 1 characterized by containing Fe:5-20% by mass % in a plating layer, and ductility.

[Claim 3] Furthermore, in a plating layer, by mass % calcium:0.001-0.1%, Mg:0.001-3%, Si: 0.001-0.1%, Mo:0.001-0.1%, W:0.001 - 0.1%, Zr: 0.001-0.1%, Cs:0.001-0.1%, Rb:0.001-0.1%, K:0.001 - 0.1%, Ag:0.001-5%, Na:0.001-0.05%, Cd: 0.001-3%, Cu:0.001-3%, nickel:0.001-0.5%, Co: 0.001-1%, La:0.001-0.1%, Ti:0.001-8%, Nd: 0.001-0.1%, Y:0.001 - 0.1%, In:0.001-5%, Be: 0.001-0.1%, Cr:0.001-0.05%, Pb:0.001-1%, Hf: 0.001-0.1%, Tc:0.001-0.1%, Ti:0.001-0.1%, germanium: The high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing according to claim 1 or 2 characterized by containing one sort of 0.001-5%, Ta:0.001-0.1%, V:0.001 - 0.2%, and B:0.001 - 0.1%**, or two sorts or more, and ductility.

[Claim 4] The high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing given in any 1 term of claims 1-3 characterized by the mean particle diameter of the austenite which is the 2nd phase of a steel plate, and/or martensite being 0.01 to 0.7 times the mean particle diameter of a ferrite, and ductility.

[Claim 5] The microstructure of a steel plate is [the mean particle diameter of *Perilla frutescens* (L.) Britton var. *crispa* (Thunb.) Decne.] 20 micrometers or less as the main phase about 50 - 95% of ferrite in a volume fraction. 3 - 30% of austenite and/or martensite are contained with a volume fraction as the 2nd phase. The high intensity melting Zn plating steel plate which those mean diameters of are 10 micrometers or less, and was excellent in the plating adhesion at the time of high processing given in any 1 term of claims 1-4 characterized by consisting of 2 - 47% of bainite with a volume fraction further, and ductility.

[Claim 6] The high intensity melting Zn plating steel plate steel excelled [steel plate] in the plating adhesion at the time of high processing given in any 1 term of claims 1-5 characterized by containing

Mo:0.001-5% by mass %, and ductility further.

[Claim 7] The high intensity melting Zn plating steel plate steel excelled [steel plate] in the plating adhesion at the time of high processing given in any 1 term of claims 1-6 characterized by containing one sort (Cr:0.001-25%, nickel:0.001-10%, Cu:0.001-5%, and Co:0.001-5%) or two sorts or more by mass %, and ductility further.

[Claim 8] The high intensity melting Zn plating steel plate steel excelled [steel plate] in the plating adhesion at the time of high processing given in any 1 term of claims 1-7 characterized by containing one sort of Nb, Ti, and V, or two sorts or more 0.001 to 1% in total by mass %, and ductility further.

[Claim 9] The high intensity melting Zn plating steel plate steel excelled [steel plate] in the plating adhesion at the time of high processing given in any 1 term of claims 1-8 characterized by containing B:0.0001 - 0.1% by mass %, and ductility further.

[Claim 10] The high intensity hot-dip zinc-coated carbon steel sheet steel excelled [hot-dip zinc-coated carbon steel sheet] in the plating adhesion at the time of high processing given in any 1 term of claims 1-9 characterized by containing one sort of Zr, Hf, and Ta, or two sorts or more 0.001 to 1.0% in total by mass %, and ductility further.

[Claim 11] The high intensity hot-dip zinc-coated carbon steel sheet steel excelled [hot-dip zinc-coated carbon steel sheet] in the plating adhesion at the time of high processing given in any 1 term of claims 1-10 characterized by containing W:0.001 - 5% by mass %, and ductility further.

[Claim 12] The high intensity hot-dip zinc-coated carbon steel sheet steel excelled [hot-dip zinc-coated carbon steel sheet] in the plating adhesion at the time of high processing given in any 1 term of claims 1-11 characterized by containing S:0.0001 - 0.01% P:0.0001 to 0.1% by mass %, and ductility further.

[Claim 13] The high intensity hot-dip zinc-coated carbon steel sheet steel excelled [hot-dip zinc-coated carbon steel sheet] in the plating adhesion at the time of high processing given in any 1 term of claims 1-12 characterized by containing 0.0001 - 0.1% for one or more sorts of Y and rare earth elements (Rem) by mass %, and ductility further.

[Claim 14] The high intensity hot-dip zinc-coated carbon steel sheet excellent in fatigue endurance given in any 1 term of claims 1-13 characterized by the amount of Si of steel being 0.001 - 2.5%, and corrosion resistance.

[Claim 15] The casting slab which becomes any 1 term of claims 1-14 from the steel component of a publication of a publication is again heated, as [casting] or once cooling. After [acid washing] cold-rolling of the hot rolled sheet steel rolled round after hot-rolling is carried out, and they are after that and $0.1x(\text{Ac3}-\text{Ac1})+\text{Ac1}$. After annealing more than (degree C) in the temperature region below $\text{Ac3}+50$ (degree C) for 10 seconds to 30 minutes It cools in a 650-700-degree C temperature region with the cooling rate of 0.1-10 degrees C/second. After cooling with the cooling rate of 1-100 degrees C/second succeeding to the plating bath temperature - plating bath temperature +100 (degree C), Hold for 1 second to 3000 seconds in the temperature region of Zn plating bath temperature - Zn plating bath temperature +100 (degree C) including consecutive plating immersion time amount, and it is immersed in Zn plating bath. The manufacture approach of a high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing characterized by cooling to a room temperature after that, and ductility.

[Claim 16] The manufacture approach of a high intensity melting Zn plating steel plate of having excelled in the plating adhesion at the time of high processing according to claim 15 characterized by performing alloying processing at further 300-550 degrees C, and cooling to a room temperature after that, and ductility after being immersed in Zn plating bath.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the high intensity hot-dip zinc-coated carbon steel sheet excellent in the ductility suitable for building materials, home electronics, an automobile, etc., and its manufacture approach.

[0002]

[Description of the Prior Art] Hot dip zincing is given for the purpose of the corrosion prevention of a steel plate, and is used for large areas, such as building materials, home electronics, and an automobile. as the manufacturing method -- continuation Rhine -- setting -- after cleaning washing and a non-oxidizing atmosphere -- heating -- H₂ And N₂ ZENJIMA called cooling after having cooled to near the plating bath temperature after annealing in the reducing atmosphere to include, cooling or reheating after being immersed in a melting zinc bath and making a Fe-Zn alloy phase generate -- there is law and it is used abundantly at processing of a steel plate.

[0003] About annealing before plating, it does not pass through heating in a non-oxidizing atmosphere after cleaning washing, but is H₂ immediately. And N₂ All the reducing furnace methods that perform annealing in the reducing atmosphere to include may also be held. Moreover, in the steel plate, cleaning and after carrying out acid washing, flux processing is performed using an ammonium chloride etc. and flux growth of immersion and after that cooling is also carried out to the plating bath.

[0004] During the plating bath used by these plating processings, aluminum little for deoxidation of melting zinc is added. In the ZENJIMA method, Zn plating bath contains about 0.1% of aluminum by mass %. the time of steel being immersed in a plating bath, since aluminum under this bath has the affinity stronger than Fe-Zn with Fe -- a steel front face -- concentration of a Fe-aluminum alloy phase, i.e., aluminum, -- a layer generates and controlling the reaction of Fe-Zn is known. concentration of aluminum -- since a layer exists, aluminum content in the obtained plating layer usually becomes higher than aluminum content under plating bath.

[0005] In recent years, especially in an automobile car body, the need of a ductile high high intensity steel plate is increasing from a viewpoint of the formation of car-body lightweight aiming at the improvement in fuel consumption. On the other hand, in various alloys' being added by the high intensity steel plate, the heat treatment approach also has big constraint from a viewpoint which reconciles high-intensity-izing and the formation of the Takanobu nature by organization control.

[0006] However, if the content of Si or aluminum becomes high also in the alloy content in steel, considering the viewpoint of plating or heat treatment conditions have big constraint In having used the plating bath containing usual aluminum, plating wettability falls greatly, and since un-galvanizing occurs, even if appearance quality deteriorates or plating is possible with **, although it is the Takanobu nature therefore, the adhesion at the time of high-processing it will deteriorate.

[0007] Although plating nature is improved by giving specific plating as a means to solve this problem so that JP,3-28359,A, JP,3-64437,A, etc. may see, by this approach, a plating facility must newly be formed in the hot-dipping Rhine annealing furnace preceding paragraph, or plating processing must be

beforehand performed in electroplating Rhine, and there is a trouble of becoming a steep cost rise.

[0008] Moreover, the hot-dip zinc-coated carbon steel sheet which has a Zn-aluminum-Mn-Fe system plating layer by JP,5-230608,A for the purpose of the plating manufacturability improvement of a high intensity steel plate is indicated. However, this invention is not invention considered about the plating adhesion at the time of high processing by high intensity and the Takanobu nature material, although sufficient consideration especially for manufacturability is paid.

[0009] Moreover, a ferrite is made into the main phase for the purpose of raising collision energy-absorbing ability at JP,11-189839,A, the mean particle diameter is 10 micrometers or less, and it consists of 3 - 50% of austenite, or 3 - 30% of martensite with a volume fraction as the 2nd phase, and the mean particle diameter of the 2nd phase is 5 micrometers or less, and the steel plate which contains bainite alternatively is indicated. However, this invention is not invention which can respond to the thinning accompanying high-intensity-izing in respect of corrosion resistance regardless of plating

[0010]

[Problem(s) to be Solved by the Invention] This invention solves the above-mentioned technical problem, and aims at offering the outstanding high intensity hot-dip zinc-coated carbon steel sheet and its manufacture approach of the ductility which has improved the plating adhesion at the time of ungalvanizing or high processing.

[0011]

[Means for Solving the Problem] As a result of examining many things, this invention persons are making a plating layer carry out proper concentration content of the specific element first, and found out that the hot-dip-zincing wettability of a high intensity steel plate improved. Moreover, the thing for which this effectiveness is strengthened by reducing aluminum concentration in a plating phase, Furthermore, Si content:X (mass %) of steel, Mn content:Y of steel (mass %), aluminum content of steel : when Z (mass %), aluminum content:A (mass %) of a plating layer, and Mn content:B (mass %) of a plating layer consider as the steel which fills $3-(10+Z [X+Y/3])-12.5x(A-B) \geq 0$, and a plating presentation It found out being obtained also about the high intensity steel plate with which very good plating contains an alloy element comparatively so much. Furthermore, even if it eased heat treatment conditions by specifying the microstructure of a steel plate in addition to choosing and optimum dose adding an alloy element, it found out that manufacture of a ductile high steel plate was possible.

[0012] This invention is as follows the place which was completed based on the above-mentioned knowledge and made into the summary.

(1) At mass %, it is C. : On the front face of the steel plate which contains 0.0001 - 0.3%, Si:0.01-2.5%, Mn:0.01-3%, and aluminum:0.001-4%, and consists of the remainder Fe and an unescapable impurity, by mass % aluminum:0.001-0.5% and Mn:0.001-2% are contained. It is the hot-dip zinc-coated carbon steel sheet which has the plating layer which the remainder becomes from Zn and an unescapable impurity. Si content of steel : Mn content:Y (mass %) of X (mass %) and steel, aluminum content:Z of steel (mass %), aluminum content of a plating layer : A (mass %) and Mn content:B (mass %) of a plating layer The following (I) type is filled and the microstructure of a steel plate is [the mean particle diameter of *Perilla frutescens* (L.) Britton var. *crispa* (Thunb.) Decne.] 20 micrometers or less as the main phase about 70 - 97% of ferrite in a volume fraction. The high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing which consists of 3 - 30% of austenite, and/or martensite with a volume fraction as the 2nd phase, and is characterized by the mean particle diameter of the 2nd phase being 10 micrometers or less, and ductility.

$3-(10+Z [X+Y/3])-12.5x(A-B) \geq 0 \dots (I)$

(2) It is in a plating phase further. High intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing given in (1) characterized by containing Fe:5-20%, and ductility.

(3) In a plating layer, by mass % further calcium:0.001-0.1%Mg:0.001-3%Si:0.001-0.1%Mo:0.001-0.1%W:0.001-0.1%Zr:0.001-0.1%Cs:0.001-0.1%, Rb:0.001-0.1%, K:0.001 - 0.1%, Ag:0.001-5%, Na:0.001-0.05%, Cd: 0.001-3%, Cu:0.001-3%, nickel:0.001-0.5%, Co: 0.001-1%, La:0.001-0.1%,

Ti:0.001-8%, Nd: 0.001-0.1%, Y:0.001 - 0.1%, In:0.001-5%, Be: 0.001-0.1%, Cr:0.001-0.05%, Pb:0.001-1%, Hf: 0.001-0.1%, Tc:0.001-0.1%, Ti:0.001-0.1%, germanium: The high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing given in (1) characterized by containing one sort of 0.001-5%, Ta:0.001-0.1%, V:0.001 - 0.2%, and B:0.001 - 0.1% **, or two sorts or more, or (2), and ductility.

(4) a steel plate -- the -- two -- a phase -- it is -- an austenite -- and/or -- martensite -- mean particle diameter -- a ferrite -- mean particle diameter -- 0.01 - 0.7 -- a time -- it is -- things -- the description -- ** -- carrying out -- (-- one --) - (-- three --) -- some -- one -- a term -- a publication -- high -- processing -- the time -- plating -- adhesion -- and -- ductility -- having excelled -- high intensity -- melting -- Zn -- plating -- a steel plate .

(5) The microstructure of a steel plate is [the mean particle diameter of *Perilla frutescens* (L.) Britton var. *crispa* (Thunb.) Decne.] 20 micrometers or less as the main phase about 50 - 95% of ferrite in a volume fraction. 3 - 30% of austenite and/or martensite are contained with a volume fraction as the 2nd phase. The high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing given in any 1 term of (1) - (4) which those mean diameters are 10 micrometers or less, and is characterized by consisting of 2 - 47% of bainite with a volume fraction further, and ductility.

(6) The high intensity melting Zn plating steel plate steel excelled [steel plate] in the plating adhesion at the time of high processing given in any 1 term of Mo:(1) characterized by containing 0.001 - 5% - (5), and ductility by mass % further.

(7) steel -- further -- mass -- % -- Cr -- : -- 0.001 - 25 -- % -- nickel -- : -- 0.001 - ten -- % -- Cu -- : -- 0.001 - five -- % -- Co -- : -- 0.001 - five -- % -- one -- a sort -- or -- two -- a sort -- more than -- containing -- things -- the description -- ** -- carrying out -- (-- one --) - (-- six --) -- some -- one -- a term -- a publication -- high -- processing -- the time -- plating -- adhesion -- and -- ductility -- having excelled -- high intensity -- melting -- Zn -- plating -- a steel plate .

(8) steel -- further -- mass -- % -- Nb -- Ti -- V -- one -- a sort -- or -- two -- a sort -- more than -- the sum total -- 0.001 - one -- % -- containing -- things -- the description -- ** -- carrying out -- (-- one --) - (-- seven --) -- some -- one -- a term -- a publication -- high -- processing -- the time -- plating -- adhesion -- and -- ductility -- having excelled -- high intensity -- melting -- Zn -- plating -- a steel plate .

(9) The high intensity melting Zn plating steel plate steel excelled [steel plate] in the plating adhesion at the time of high processing given in any 1 term of (1) - (8) characterized by containing B:0.0001 - 0.1% by mass %, and ductility further.

(10) steel -- further -- mass -- % -- Zr -- Hf -- Ta -- one -- a sort -- or -- two -- a sort -- more than -- the sum total -- 0.001 - 1.0 -- % -- containing -- things -- the description -- ** -- carrying out -- (-- one --) - (-- nine --) -- some -- one -- a term -- a publication -- high -- processing -- the time -- plating -- adhesion -- and -- ductility -- having excelled -- high intensity -- a hot-dip zinc-coated carbon steel sheet .

(11) The high intensity hot-dip zinc-coated carbon steel sheet steel excelled [hot-dip zinc-coated carbon steel sheet] in the plating adhesion at the time of high processing given in any 1 term of (1) - (10) characterized by containing W:0.001 - 5% by mass %, and ductility further.

(12) The high intensity hot-dip zinc-coated carbon steel sheet steel excelled [hot-dip zinc-coated carbon steel sheet] in mass % further at the plating adhesion and ***** at the time of high processing given in any 1 term of (1) - (11) characterized by containing S:0.0001 - 0.01% P:0.0001 to 0.1%.

(13) steel -- mass -- % -- Y -- rare earth elements (Rem) -- one -- a sort -- more than -- 0.0001 - 0.1 -- % -- containing -- things -- the description -- ** -- carrying out -- (-- one --) - (-- 12 --) -- some -- one -- a term -- a publication -- high -- processing -- the time -- plating -- adhesion -- and -- ductility -- having excelled -- high intensity -- a hot-dip zinc-coated carbon steel sheet .

(14) The high intensity hot-dip zinc-coated carbon steel sheet excellent in fatigue endurance given in any 1 term of (1) - (3) characterized by the amount of Si of steel being 0.001 - 2.5%, and corrosion resistance.

(15) (1) The casting slab which becomes any 1 term of - (14) from the steel component of a publication of a publication is again heated, as [casting] or once cooling. After [acid washing] cold-rolling of the hot rolled sheet steel rolled round after hot-rolling is carried out, and they are after that and 0.1x(Ac3-

Ac1)+Ac1. After annealing more than (degree C) in the temperature region below Ac3 +50 (degree C) for 10 seconds to 30 minutes It cools in a 650-700-degree C temperature region with the cooling rate of 0.1-10 degrees C/second. After cooling with the cooling rate of 1-100 degrees C/second succeeding to the plating bath temperature - plating bath temperature +100 (degree C), Hold for 1 second to 3000 seconds in the temperature region of Zn plating bath temperature - Zn plating bath temperature +100 (degree C) including consecutive plating immersion time amount, and it is immersed in Zn plating bath. The manufacture approach of a high intensity melting Zn plating steel plate excellent in the plating adhesion at the time of high processing characterized by cooling to a room temperature after that, and ductility.

(16) The manufacture approach of a high intensity melting Zn plating steel plate of having excelled in the plating adhesion at the time of high processing given in (15) characterized by performing alloying processing at further 300-550 degrees C, and cooling to a room temperature after that, and ductility after being immersed in Zn plating bath.

[0013] In addition, among this specification, when refusing especially about the content of each chemical composition components, such as steel, and C, Si, Mn, aluminum of a plating layer, and only displaying it as "%" that there is nothing, "mass %" is meant.

[0014]

[Embodiment of the Invention] Hereafter, this invention is explained to a detail.

[0015] this invention persons are mass %s. C:0.0001 - 0.3%, Si:0.001-2.5%, Mn: It is 0.1x(Ac3-Ac1) +Ac1 about the steel plate which contains 0.01-3% and aluminum:0.001-4%, and consists of the remainder Fe and an unescapable impurity. It anneals below by Ac3 +50 (degree C) more than (degree C) for 10 seconds to 30 minutes. It cools in a 650-700-degree C temperature region with the cooling rate of 0.1-10 degrees C/second. After cooling with the cooling rate of 1-100 degrees C/second succeeding to the plating bath temperature (450-470 degrees C) - plating bath temperature +100 (degree C), immersion was carried out to 450-470-degree C Zn plating bath for 3 seconds, and heating was performed for 10 to 60 seconds at further 500-550 degrees C. Then, measuring the non-galvanized aspect product of a plating steel plate front face estimated plating nature, and the tensile test estimated the mechanical property, respectively. Furthermore, in order to evaluate plating adhesion, after giving 20% of tension distortion and performing 60-degree bending-bending return processing, the vinyl tape was stuck in the bending section, it stripped, and quantifying the stripped plane product of plating with the amount of image analyses estimated. From the result of such a trial, as Si content:X in steel (mass %), and Mn content in steel:Y (mass %), aluminum content in steel:Z (mass %), aluminum content in plating layer:A (mass %), and Mn content in plating layer:B (mass %) When arranged, header this invention was completed for there being no un-galvanizing and a high intensity hot-dipping steel plate with good adhesion with the steel plate of the plating after tension and bending being obtained by the presentation with which the following (I) type is filled.

[0016]

$3-(10+Z [X+Y/3]-12.5x(A-B)) \geq 0 \dots (I)$

(I) A formula is a formula newly found out by the multiple regression analysis which arranged the effect of the steel plate exerted on plating wettability, and a plating component.

[0017] They are aluminum added during the plating bath although it was unknown about the detail of the reason non-galvanized generating is controlled, and SiO₂ generated on the steel plate front face. Since wettability is bad, it is thought that un-galvanizing occurs. That is, it becomes possible to control non-galvanized generating by adding the element from which the bad influence of aluminum added to Zn bath is removed. As a result of this invention persons' inquiring wholeheartedly, it became clear that the notation purpose could be attained by adding Mn by the proper density range during a plating bath. Mn forms an oxide film more preferentially than aluminum added during Zn bath, and is presumed to be what raises reactivity with the oxide film of Si system currently generated on the steel plate front face.

[0018] About plating coating weight, although especially constraint is not prepared, it is desirable that they are two or more 5 g/m in a corrosion resistance viewpoint to one side coating weight. Even if it performs performing the upper plating in order to improve paintwork and weldability on the melting Zn

plating steel plate of this invention, various kinds of processings, for example, chromate treatment, phosphating, processing on a lubrication disposition, the improvement processing in weldability, etc., it does not deviate from this invention.

[0019] The amount of aluminum in a plating layer was made into 0.001 - 0.5% of range because it became difficult to control an alloying reaction remarkably if aluminum is added exceeding that an appearance remarkable [dross generating] and good at less than 0.001% is not acquired and 0.5%, and to form an alloying hot-dip-zincing layer.

[0020] The amount of Mn in a plating layer was made into 0.001 - 2% of within the limits, because un-galvanizing did not occur in this range but the plating of a good appearance was obtained. If the amount of Mn exceeds 2% of an upper limit, a Mn-Zn compound deposits in a plating bath, and an appearance falls remarkably by being incorporated in a plating layer.

[0021] Moreover, when especially spot welding nature and paintwork are desired, alloying processing can raise these properties. By performing alloying processing of a publication to invention which starts above (15), Fe is incorporated in a plating layer and the high intensity hot-dip zinc-coated carbon steel sheet which was excellent at paintwork or spot welding nature can be obtained. The amount of Fe(s) after alloying processing becomes insufficient [less than 5% / spot welding nature]. On the other hand, if the amount of Fe(s) exceeds 20%, the adhesion of the plating layer itself will be spoiled, and it becomes the cause of the crack at the time of shaping because a plating layer adheres to destruction and a dechiller mold in the case of processing. Therefore, the range of the amount of Fe(s) in a plating layer in the case of performing alloying processing is made into 5 - 20%.

[0022] They are aluminum added during the plating bath although it was unknown about the detail of the reason non-galvanized generating is controlled, as above-mentioned, and SiO₂ generated on the steel plate front face. Since wettability is bad, it is thought that un-galvanizing occurs. That is, it becomes possible to control non-galvanized generating by adding the element from which the bad influence of aluminum added to Zn bath is removed. As a result of this invention persons' inquiring wholeheartedly, the notation purpose can be attained by adding Mn by the proper density range as mentioned above. Mn forms an oxide film more preferentially than aluminum added during Zn bath, and is presumed to be what raises reactivity with the oxide film of Si system currently generated on the steel plate front face.

[0023] It found out that un-galvanizing was controlled by furthermore containing one sort of calcium, Mg, Si, Mo, W, Zr, Cs, Rb, K, Ag, Na, Cd, Cu, nickel, Co, La, Tl, Nd, Y, In, Be, Cr, Pb, Hf, Tc, Ti, germanium, Ta, V, and B, or two sorts or more within limits explained below in a plating layer.

[0024] Although especially constraint is not prepared about plating coating weight, they are 5 g/m² at a corrosion resistance viewpoint to one side coating weight. It is desirable that it is above. Even if it performs performing the upper plating in order to improve paintwork and weldability on the melting Zn plating steel plate of this invention, various kinds of processings, for example, chromate treatment, phosphating, processing on a lubrication disposition, the improvement processing in weldability, etc., it does not deviate from this invention.

[0025] The amount of Mg 0.001 to 0.1% for the amount of calcium in a plating layer 0.001 - 3%, 0.001 to 0.1 mass %, and the amount of Mo for the amount of Si 0.001 to 0.1 mass %, 0.001 to 0.1 mass %, and the amount of Zr for the amount of W 0.001 to 0.1 mass %, 0.001 to 0.1 mass %, and the amount of Rb(s) for the amount of Cs 0.001 to 0.1 mass %, 0.001 to 0.1 mass %, and the amount of Ag for the amount of K 0.001 to 5 mass %, 0.001 to 0.05 mass %, and the amount of Cd(s) for the amount of Na 0.001 to 3 mass %, 0.001 to 3 mass %, and the amount of nickel for the amount of Cu(s) 0.001 to 0.5 mass %, 0.001 to 1 mass %, and the amount of La(s) for the amount of Co(es) 0.001 to 0.1 mass %, 0.001 to 8 mass %, and the amount of Nd(s) for the amount of Tl 0.001 to 0.1 mass %, 0.001 to 0.1 mass %, and the amount of In(s) for the amount of Y 0.001 to 5 mass %, 0.001 to 0.1 mass %, and the amount of Cr(s) for the amount of Be(s) 0.001 to 0.05 mass %, 0.001 to 1 mass %, and the amount of Hf(s) for the amount of Pb(s) 0.001 to 0.1 mass %, 0.001 to 0.1 mass %, and the amount of Ti for the amount of Tc 0.001 to 0.1 mass %, The amount of 0.001 - 0.1 mass %V was made into 0.001 to 0.2 mass %, and the amount of B was made [the amount of germanium] into within the limits of 0.001 - 0.1 mass % for 0.001 to 5 mass %, and the amount of Ta, because un-galvanizing was controlled in this range,

respectively and the plating of a good appearance was obtained. If the content of each element exceeds an upper limit, by generation of the dross containing each element, a plating appearance will fall remarkably.

[0026] Next, the reason for limitation of the steel plate component in this invention is explained.

[0027] C is an element added in order to secure enough the volume fraction of the 2nd phase for securing good on-the-strength ductility balance. When especially the 2nd phase is an austenite, it contributes not only to a volume fraction but to its improvement in stability, and ductility is raised greatly. In order to secure reinforcement and the volume fraction of each 2nd phase, the minimum was made into 0.0001%, and it considered as the upper limit which can hold weldability, and could be 0.3%.

[0028] Si is an element added in order to control generation of the carbide which degrades promoting the ferrite generation which is the main phase, and on-the-strength ductility balance, and made the minimum 0.01%. Moreover, superfluous addition made the upper limit 2.5% in order to have a bad influence on weldability and plating wettability. Moreover, when an appearance became a problem especially from reinforcement, it carried out to your making it decrease to 0.001% which does not pose a manufacture operation top problem.

[0029] In addition to control of plating wettability and adhesion, it added in order to control the carbide deposit and pearlite generation which are one cause of high-intensity-izing and ductility degradation, and Mn could be 0.01% or more. On the other hand, since making the transformation to bainite which contributes to the improvement in ductility delayed, and weldability were degraded when the 2nd phase was an austenite, 3% was made into the upper limit.

[0030] In addition to control of plating wettability and adhesion, aluminum is effective in promoting the transformation to bainite which contributes to the improvement in ductility, when the improvement in ductility, especially the 2nd phase are austenites, and it raises on-the-strength ductility balance. For this reason, it considered as 0.001% or more of addition. On the other hand, superfluous addition made 4% the upper limit in order to spoil weldability and plating wettability.

[0031] Mo is the element which can be added in order to control generation of the carbide and the pearlite which degrade on-the-strength ductility balance, and in order to obtain good on-the-strength ductility balance under the eased heat treatment condition, it is an important alloying element. 0.001% of the minimum is desirable. Moreover, since superfluous addition causes ductility degradation, 5% of an upper limit is desirable.

[0032] Furthermore, the target steel [this invention] can contain one sort of Cr, nickel, Cu, and Co, or two sorts or more for the purpose of the further improvement in reinforcement.

[0033] Cr is the element added from the strengthening purpose and the purpose of control of carbide generation, and it is desirable to consider as 0.001% or more, and to make this into an upper limit in addition of the amount exceeding 25%, in order to have a bad influence on workability.

[0034] As for nickel, it is desirable to consider as 0.001% or more a plating disposition top and for the purpose of strengthening, and to make this into an upper limit in addition of the amount exceeding 10%, in order to have a bad influence on workability.

[0035] Since there is an inclination which has a bad influence on workability in addition of the amount which Cu considers as 0.001% or more, of addition for the purpose of strengthening, and exceeds 5%, 5% of an upper limit is [a minimum] desirable 0.001%.

[0036] Co was taken as 0.001% or more of addition for improvement in the on-the-strength ductility balance by plating nature control and transformation-to-bainite control. Although especially the upper limit of addition is not established, since it is an expensive element on the other hand, as for abundant addition, it is desirable to make it to 5% or less in order to spoil economical efficiency.

[0037] Furthermore, the target steel [this invention] can contain one sort of Nb, Ti, and V which are a strong carbide formation element, or two sorts or more for the purpose of the further improvement in reinforcement. These elements form detailed carbide, a nitride, or carbon nitride, and since that of strengthening of a steel plate is very effective, it is desirable to add one sort or two sorts or more 0.001% or more if needed. On the other hand, since ductility degradation and concentration of C to the inside of retained austenite are checked, as an upper limit of a sum total addition, 1% is desirable.

[0038] B can also be added if needed. Although B is effective in strengthening of a grain boundary, or high-intensity-izing of steel materials at 0.0001% or more of addition, since the effectiveness is not only saturated, but it will raise steel plate reinforcement beyond the need and workability will fall if the addition exceeds 0.1%, as for an upper limit, considering as 0.1% is desirable.

[0039] One sort of Zr, Hf, and Ta which are a strong carbide formation element, or two sorts or more can be contained for the purpose of the further improvement in reinforcement.

[0040] These elements formed detailed carbide, a nitride, or carbon nitride, and since it was very effective in strengthening of a steel plate, they considered one sort or two sorts or more as the addition more than 0.001 mass % if needed. while -- as the upper limit of a sum total addition since ductility degradation and concentration of C to the inside of retained austenite are checked -- 1.0 mass % -- ** -- it carried out.

[0041] Having made the amount of W into the range of 0.001 - 5 mass % made the upper limit that the strengthening effectiveness shows up above 0.001 mass %, and 5 mass % for having a bad influence on workability at addition of the amount exceeding this.

[0042] Since, as for having made the amount of P into the range of 0.0001 - 0.05 mass %, the strengthening effectiveness's showing up above 0.0001 mass % and super-low-izing were economically disadvantageous, they made this the minimum. Moreover, 0.1 mass % was made into the upper limit at addition of the amount exceeding this for having a bad influence on the manufacturability at weldability or the time of casting and hot-rolling.

[0043] Since super-low-izing was economically disadvantageous, having made the amount of S into the range of 0.0001 - 0.01 mass % made 0.0001 mass % the minimum, and 0.1 mass % was made into the upper limit at addition of the amount exceeding this for having a bad influence on the manufacturability at weldability or the time of casting and hot-rolling.

[0044] Having made Y and the amount of rare earth elements (REM) into the range of 0.0001 - 0.1 mass % has improved wettability above 0.0001 mass %, and it made 0.1 mass % the upper limit at addition of the amount exceeding this for having a bad influence on the manufacturability at weldability or the time of casting and hot-rolling.

[0045] As other unescapable impurities, although there is Sn etc., it is desirable that it is the range not more than $\text{Sn} \leq 0.01\%$.

[0046] Next, the microstructure of a base material steel plate is described. In order to fully secure ductility, it is required to make the main organization into a ferrite phase. However, when further pointed to high intensity-ization, the bainite phase could also be included 2% or more with the volume fraction, but when a bainite phase was not included from a viewpoint which secures ductility, and a bainite phase was included 70% or more with a volume fraction, it was presupposed that a ferrite is contained 50% or more with a volume fraction.

[0047] Although the increment in the volume fraction of a ferrite raises ductility, since it is connected with a fall on the strength, when it does not contain a bainite phase and an upper limit contains a bainite phase 97% with a volume fraction, it is made into 95% with a volume fraction. Moreover, in order to reconcile high intensity and the Takanobu nature, it considers as the complex tissue containing retained austenite and/or martensite. For high intensity and the Takanobu nature, a retained austenite phase and/or martensite were made into a total of 3% or more with the volume fraction. This was made into the upper limit in order to show an embrittlement inclination, when a volume fraction exceeds a total of 30%.

[0048] In order to maintain the manufacturability in the heat treatment conditions which can secure plating nature, and the adhesion of the plating at the time of high processing and to fully secure the ductility of the steel plate itself, mean particle diameter of a ferrite is set to 20 micrometers or less, and the mean particle diameter of the austenite which is the 2nd phase, and/or martensite is specified as 10 micrometers or less.

[0049] Furthermore, in order to make balance of plating adhesion and ductility good, it is desirable to use the 2nd phase as an austenite and/or martensite, and to secure 0.7 or less ratio to the mean particle diameter of the ferrite which is the main phase. Since a real manufacture top is difficult for the mean

particle diameter of the austenite which is the 2nd phase on the other hand, and/or martensite, it is [considering as less than 0.01 times of the mean particle diameter of a ferrite] desirable that they are 0.01 or more times.

[0050] It is as follows when a volume fraction in case bainite is included etc. is explained. When useful to high intensity-ization by containing 2% or more with a volume fraction, if a bainite phase coexists with an austenite phase, it will contribute to austenite stabilization and will be useful to high n value-ization as a result. Moreover, this phase is fundamentally detailed and contributes also to the plating adhesion at the time of high processing. If the volume fraction of bainite is made into 2% or more when especially the 2nd phase is an austenite, the balance of plating adhesion and ductility will improve further. On the other hand, if it generates too much, since a ductility fall will be caused, a bainite phase may be 47% or less with a volume fraction.

[0051] Although it is the criteria of the steel plate of this invention as a remainder organization of a microstructure also when it contains 1 of carbide, a nitride, a sulfide, and an oxide, or two sorts or more other than the above, as for these one sort or two sorts or more, it is desirable that it is 1% or less in a volume fraction. In addition, observation of identification of the ferrite, the bainite, the austenite, the martensite, and the remainder organization of the above-mentioned microstructure and an existence location and measurement of mean particle diameter (average projected area diameter) and a space factor corrode a steel plate rolling direction cross section, or a rolling direction and a right-angled cross section with the reagent indicated by a NAITARU reagent and JP,59-219473,A, and can quantify them by 1000 times [500 times to] as many optical microscope observation as this.

[0052] Mean particle diameter is defined as the value calculated by JIS based on the result of which beyond 20 visual-field observation was done by the above-mentioned approach.

[0053] The manufacture approach of a high intensity hot-dip zinc-coated carbon steel sheet of having such an organization is explained below.

[0054] After [hot-rolling] cold-rolling, and in annealing and manufacturing the steel plate of this invention, it considers as a final product because reheat as [casting] or once cooling, hot-roll, carry out acid washing of the slab adjusted to the same component as the steel plate component of invention concerning aforementioned (1) - (13) after that and it carries out cold-rolled afterbaking dull. Especially the cooling conditions of slab can acquire the effectiveness of this invention, without limiting. Reheating temperature is Ar3 in order to secure the completion temperature of hot-rolling. It is desirable to carry out above the temperature of transformation. It is Ar3 although it is common to carry out by the 3 or more temperature of transformation of Ar(s) it is decided by the chemical entity of steel at this time that the completion temperature of hot-rolling will be. From the temperature of transformation, if about 10 degrees C is to low temperature, degradation is [the property of a final steel plate] avoidable.

Moreover, when the rate of the bottom of total pressure of cold-rolling is small, even if it is rolled round below not by this limitation but by the bainite temperature of transformation of steel, degradation is [the property of a final steel plate] avoidable, although raising the load at the time of cold-rolling beyond the need is avoided by carrying out winding temperature after cooling to beyond the transformation-to-bainite initiation temperature decided by the chemical entity of steel. Moreover, although set up from the relation between the last board thickness and a cold-rolled load, if the rate of the bottom of total pressure of cold-rolling is 40% or more, it can avoid degradation for the property of a final steel plate.

[0055] Temperature Ac1 it is decided by the chemical entity of steel that annealing temperature will be in case it carries out cold-rolled afterbaking dull And Ac3 At temperature (for example, "ferrous material study":wcLeslie work, Nariyasu Koda supervision of translation, Maruzen P273) $0.1 \times (Ac3 - Ac1) + Ac1$ expressed Since the case of under (degree C) had few amounts of austenites obtained with annealing temperature, and it was not able to leave a retained austenite phase or a martensitic phase into a final steel plate, this was made into the minimum of annealing temperature. Moreover, even if annealing temperature exceeds $Ac3 + 50$ (degree C), in order to be unable to improve the property of a steel plate at all but to cause the rise of a manufacturing cost, the upper limit of annealing temperature was set to $Ac3 + 50$ (degree C). 10 seconds or more are required for the annealing time amount in this temperature because of reservation of the purpose which controls the particle size of the main phase and

the 2nd phase in addition to temperature equalization of a steel plate, and an austenite. Although it is dependent also on a steel plate component, it is desirable, in order for holding in this temperature region for 3 minutes to 10 minutes to set particle size of a ferrite and the 2nd phase to 20 micrometers and 10 micrometers or less and to set the ratio of particle size to 0.01-0.7. However, by **, grained big and rough-ization is caused for 30 minutes depending on a steel plate component. Moreover, since the rise of cost was caused, this was made into the upper limit.

[0056] The subsequent primary cooling of concrete is important for urging the transformation to a ferrite phase from an austenite phase, condensing C in a non-metamorphosed austenite phase, and achieving austenite stabilization. moreover, the cooling rate here needed to be controlled also from the purpose which controls the particle size of the ferrite to generate, it resembled making it big and rough that this cooling rate carries out [second] in less than 0.1 degrees C /, and in addition, since the demerit on manufacture of lengthening required production-line length or making a production rate very late was produced, the minimum of this cooling rate was carried out in 0.1 degrees C/second. On the other hand, since a ferrite transformation did not fully take place, but the retained austenite phase reservation in a final steel plate became difficult or hard phases, such as a martensitic phase, became abundant when a cooling rate is 10-degree-C [/] second **, this was made into the upper limit.

[0057] If this primary cooling of concrete was performed to less than 650 degrees C, since a pearlite would generate during cooling, C which is an austenite stabilization element would be wasted and sufficient quantity of retained austenite finally would not be obtained, this was made into the minimum. However, since advance of a ferrite transformation was not enough when cooling was performed only by 700-degree-C super-**, this was made into the upper limit.

[0058] A second is needed in at least 1 degrees C /or more as a cooling rate to which, as for the forced cooling of the secondary cooling of concrete performed succeeding, neither a pearlite transformation nor a deposit of iron carbide takes place during cooling. However, since the capacity rating top was difficult, 100-degree-C [/] super-**(ing) this cooling rate a second made a second the range of a cooling rate in 1-100 degrees C /.

[0059] If the cooling-shut-down temperature of this secondary cooling of concrete is lower than Zn plating bath temperature, it will become an operation top problem, and it becomes impossible to secure the amount of the retained austenite obtained since a carbide deposit will arise for a short time if the plating bath temperature +100 (degree C) is exceeded, or martensite. For this reason, halt temperature of secondary cooling was made into Zn plating bath temperature - Zn plating bath temperature +100 (degree C). Then, it is desirable to also hold consecutive plating immersion time amount 1 in all second or more in this temperature region from stability reservation, to promote [of plate leaping on operation] generation of bainite as much as possible, and the purpose that secures the wettability of further plating enough. Moreover, if this holding time turns into long duration, since carbide will generate on productivity the top which is not desirable, it is desirable to consider as less than 3000 seconds, without including alloying processing. At the temperature generally performed by Zn plating processing of a steel plate etc., plating bath temperature is good and is about 450-470 degrees C preferably.

[0060] The austenite phase which remains in a steel plate can be made stability at a room temperature by making the part metamorphose into a bainite phase, and raising the carbon concentration in an austenite further. In order to combine alloying processing and to promote a transformation to bainite, it is desirable to hold from 15 seconds in a 300-550-degree C temperature region for 20 minutes. Since it will become difficult for carbide to arise and to leave sufficient retained austenite phase if a transformation to bainite cannot happen easily at less than 300 degrees C and it exceeds 550 degrees C, the minimum of alloying processing temperature has 550 degrees C suitable for 300 degrees C and an upper limit.

[0061] In order to make a martensitic phase generate, unlike the case of a retained austenite phase, it is not necessary to produce a transformation to bainite. On the other hand, like a retained austenite phase, since it needs to control, it is desirable [generation of carbide or a pearlite phase] to carry out alloying processing in a 400 degrees C - 550 degrees C temperature region in order to perform sufficient alloying processing after secondary cooling.

[0062]

[Example] Hereafter, an example explains this invention to a detail further.

[0063] The steel plate of a presentation as shown in Table 1 is heated at 1200 degrees C, and it is Ar3. After acid washing, cold-rolling of the steel strip rolled round above the transformation-to-bainite initiation temperature which completes hot-rolling above the temperature of transformation, and is decided by the chemical entity of each steel after cooling was carried out, and it was made into 1.0mm thickness.

[0064] Then, the following formula is followed from the component (mass %) of each steel, and it is Ac1. Ac3 It asked for the temperature of transformation by count.

[0065] $Ac1 = 723 - 10.7 \times Mn\% + 29.1 \times Si\%$, $Ac3 = 910 - 203 \times (C\%)^{1/2} + 44.7 \times Si\% + 31.5 \times Mo\% - 30 \times Mn\% - 11 \times Cr\% + 400 \times aluminum\%$, These Ac(s)1 And Ac3 It is 10% H₂-N₂ to the annealing temperature calculated from the temperature of transformation. In an ambient atmosphere, a temperature up, after carrying out the retention, It cooled to 680 degrees C with the cooling rate of 0.1-10 degrees C/second, cooled even to plating bath temperature with the cooling rate of 1-20 degrees C/second succeedingly, and galvanized by being immersed in the 460-degree C galvanization bath to which various bath presentations were changed for 3 seconds.

[0066] Moreover, about some steel plates, as Fe-Zn alloying processing, the steel plate after Zn plating was held in the 300-550-degree C temperature region for 15 seconds to 20 minutes, and it adjusted so that Fe content in a plating layer might become 5 - 20 mass %. Visual observation of the dross contamination situation of a plating surface appearance and measurement of a non-galvanized aspect product estimated plating nature. The produced plating dissolved the plating layer by 5% solution of hydrochloric acid containing inhibitor, presented the chemical analysis with it, and searched for the presentation.

[0067] The piece of a JIS No. 5 tensile test was extracted from the steel plate which performed these Zn plating processings, and the mechanical property was measured. Furthermore, after giving 20% of tension distortion, the plating adhesion after high processing by 60-degree bending-bending return trial was evaluated. The adhesion of plating made the vinyl tape adhere to a bending part after bending-bending return, is stripping again, and measured and carried out comparative evaluation of the rate of exfoliation per unit length. Manufacture conditions are shown in Table 3.

[0068] As shown in Table 2, in there being almost no un-galvanizing and excelling in reinforcement and elongation balance, even if D1-D12 of this invention steel (39 No.1, 2, 5, 12, 13, 20, 22-24, 32, 34-36, 42) perform bending-bending return after 20% processing, the rate of plating exfoliation is as low [12] as 1% or less. Moreover, when the 4th element ("other elements in a plating phase" in Table 2) is added by the component in a plating layer, and the value of a formula (I) is comparatively low, it turns out that good plating nature is shown.

[0069] In hot-rolling of sample creation time, cracks occurred frequently and manufacturability was inferior at C1-C5 which are comparison steel on the other hand (No.44-48). Although it carried out cold-rolled annealing and was used for the material test after it carried out grinding of the obtained hot-rolling plate and it removed the crack, about the plating adhesion after high processing, it is inferior, or there were some (C2 and C4) which cannot add 20% of processing.

[0070] Moreover, about the plating adhesion after high processing, No.3 which do not fill the (I) type, and 21, 46 and 48 are inferior in the wettability of plating deteriorating. Moreover, also when not fulfilling a convention of the microstructure of a steel plate, about the plating adhesion after high processing, it is inferior.

[0071] Moreover, since No.3 have the slow secondary cooling rate, a pearlite generates them, without martensite and an austenite generating, and they are inferior about the plating adhesion after high processing.

[0072]

[Table 1]

表1 化学成分と製造性およびめっき濡れ性

鋼種 C	Si	Mn	Al	Mo	Cr	Ni	Cu	Co	Nb	Ti	V	B	Zr	Hf	Te	W	P	S	Y	REM
D1	0.18	0.45	0.55	1.12													0.02	0.005		発明例
D2	0.16	0.48	0.58	0.95	0.15												0.01	0.006		
D3	0.13	1.21	1.01	0.48	0.12												0.01	0.007		
D4	0.09	0.49	1.11	1.51	0.18												0.02	0.001		
D5	0.08	0.89	1.21	0.82	0.09	0.09											0.03	0.004		
D6	0.11	1.23	1.49	0.31			0.74	0.42			0.005						0.01	0.003		
D7	0.22	1.31	1.09	0.75	0.23				0.08								0.01	0.004		
D8	0.07	0.91	1.56	0.03					0.01	0.01							0.02	0.004		
D9	0.05	0.91	1.68	0.03	0.53	1.65						0.0028					0.01	0.002		
D10	0.18	0.11	1.1	0.87	0.08								0.01			0.05	0.02	0.03		0.0007
D11	0.17	0.21	0.9	1.2	0.38	0.1								0.01	0.02		0.03	0.02		
D12	0.21	0.11	1.05	0.78												0.25	0.01	0.03	0.009	
C1		0.32	2.81																	比較例
C2	0.27	1.22	1.97	0.03																
C3	0.05		0.8	0.05																
C4	0.08	0.21	0.4	0.06																
C5	0.15		1.32	0.02																

表中の下線は本発明の範囲外の条件。

[0073]

[Table 2]

表2 めっき層中のAl, MnおよびFe濃度とめっき性

鋼種	No	めっき層中のAl%	めっき層中のMn%	めっき層中のFe%	めっき層中の他の元素	合金化の有無	加工前腐食の有無	加工後の腐食の有無	Fe/Mn	Fe/Al	フェライトの体積分率/%	オーステナイトの体積分率/%	マルテンサイトの体積分率/%	ベイナイトの体積分率/%	フェライトとベイナイトの平均粒径/μm	オーステナイトの平均粒径/μm	マルテンサイトの平均粒径/μm	フェライトとベイナイトの平均粒径の比	20%引き加工後のめっき層の厚さ/μm	めっき性
D1	1	0.1	0.5	10	10.1		有り	無し	575	39	91.8	4.9	0	3.5	12.5	2.2		0.176	0	発明例
D1	2	0.1	0.5		10.1		無し	無し	565	42	90.8	5.3	0	3.9	12.2	2.5		0.205	0.1	発明例
D1	3	0.18					無し	微小	580	41	91.2	5.1	0	3.7	11.6	2.3		0.195	12	比較例
D1	4	0.1	0.5	11	10.1		有り	無し	530	31	85				13.5				4	比較例
D2	5	0.03	0.1	8	2.98		有り	無し	605	38	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	6	0.04	0.02	10	1.855	Mn0.01	有り	無し	605	36	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	7	0.04	0.01	9	1.73	Ga0.3, Mg0.005	有り	無し	605	36	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	8	0.04	0.01	8	1.73	Ag0.5, Ni0.1	有り	無し	605	36	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	9	0.03	0.01	9	1.855	Ni0.01, Ga0.01	有り	無し	605	36	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	10	0.04	0.01	9	1.73	Pb0.4	有り	無し	605	36	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	11	0.03	0.05	8	2.355	Te0.02	有り	無し	605	36	90.5	5.8	0	3.8	10.1	2.3		0.228	0	発明例
D2	12	0.03	0.1		2.98		無し	無し	615	37	89.5	6.2	0	4.3	10.2	2.5		0.245	0.1	発明例
D3	13	0.04	0.2	10	3.63		有り	無し	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0	発明例
D3	14	0.3	0.4	8	2.779	Si0.01	有り	無し	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0	発明例
D3	15	0.3	0.2	10	0.279	Ti0.08	有り	微小	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0.1	発明例
D3	16	0.1	0.2	8	2.779	Ni0.04	有り	無し	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0	発明例
D3	17	0.15	0.2	9	2.184	Be0.01	有り	無し	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0	発明例
D3	18	0.2	0.2	10	1.559	In0.7	有り	無し	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0	発明例
D3	19	0.4	0.3	10	0.279	K0.04	有り	無し	610	38	89.8	6.4	0	3.8	8.9	2.6		0.292	0	発明例
D3	20	0.04	0.2		3.63		無し	無し	620	38	88.8	6.7	0	4.5	8.7	2.7		0.310	0.2	発明例
D3	21	0.3		8			有り	多量	615	38	89.5	6.4	0	4.1	8.8	2.6		0.306	46	比較例
D4	22	0.02	0.05	9	2.27		有り	無し	555	40	93.7	3.5	0	2.8	11.5	2.3		0.200	0	発明例
D5	23	1	1	15	1.78		有り	無し	635	33	88.8	0	8.1	3.1	7.5		3.4	0.453	0.3	発明例
D5	24	0.15	0.1	10	0.89		有り	微小	680	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0.5	発明例
D5	25	0.15	0.2	10	2.143	Ce0.01	有り	無し	680	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0	発明例
D5	26	0.15	0.25	10	2.768	Rb0.01	有り	無し	680	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0	発明例
D5	27	0.2	0.1	10	0.268	Gd0.01	有り	微小	680	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0.1	発明例
D5	28	0.2	0.1	10	0.268	Cr0.03	有り	微小	680	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0.1	発明例
D5	29	0.15	0.05	10	0.268	Cu0.5, Ni0.2	有り	無し	685	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0	発明例
D5	30	0.25	0.15	8	0.268	Ti0.05	有り	無し	680	33	85.4	8.1	0	6.5	5.3	1.9		0.358	0	発明例

表中の下線は本発明の範囲外の条件。

*主相がフェライトとベイナイトの場合において相の定量的測定が困難である。一方では、破断伸びが20%以下と脆性であり、高加工後のめっき密着性の評価が不可能である。

**合金化元素のない場合にはめっき層中にFeはほとんど含まれない。

***各相の体積分率の合計100%となるが、炭化物、窒化物、硫化物および酸化物等の光學顕微鏡レベルでは定量測定困難な相については主相の体積分率に加えた。

[0074]

[Table 3]

表2(続き)

鋼種	No	めっき層中の			(1)式 の値	めっき層中の他 の元素	合金 化の有無	加工前 鋼板の めっきの 有無	機械的性質ミクロ組織														20%引張り 加工後の 60°曲げ- 曲げ戻し後 のめっき割 離率/%	
		Al%	Ni%	Fe% **					TS/MPa	EL/%	フェライ トの体積 分率/%	オース テナイト の体積分 率/% ***	マルテン サイトの 体積分 率/% ***	ベイナ イトの 体積分 率/% ***	過剰 炭素/% ***	フェライ トの平 均粒径 /μm	オーステ ナイトの 平均粒 径/μm	マルテン サイトの 平均粒 径/μm	フェライト と第2相 の平均粒径 の比					
D6	31	0.1	0.1	10	1.518	V:0.05	有り	無し	680	33	85.4	8.1	0	8.5	***	5.3	1.9		0.268	0	0	発明鋼		
D7	32	0.04	0.5	15	6.97		有り	微小	810	32	82.5	9.7	0	7.8	***	4.8	1.8		0.391	0.4	0	発明鋼		
D7	33	0.04	0.5	15	6.97		無し	微小	690	18	主相はフェライトとベイナイトの混合*											比較鋼		
D8	34	0.4	0.8		6.24		無し	微小	795	30	83.5	0	11.2	5.3	***	3.9		2	0.813	0.5	0	発明鋼		
D9	35	0.5	0.8		5.7		無し	微小	845	27	88.5	0	10.5	0	***	3.5		1.8	0.514	0.7	0	発明鋼		
D10	36	0.5	0.7	11	4.99	La:0.005	有り	無し	620	33	82.5	4	0	3.5	***	11	2.8		0.255	0	0	発明鋼		
D10	37	0.5	0.4	10	1.24	Zr:0.01, W:0.01	有り	微小	620	33	82.5	4	0	3.5	***	11	2.8		0.255	0	0	発明鋼		
D10	38	0.4	0.25	9	0.815	K:0.04	有り	無し	620	33	82.5	4	0	3.5	***	11	2.8		0.255	0	0	発明鋼		
D11	39	0.3	0.2		1.05	Hf:0.01	無し	無し	670	31	83.3	0	8.2	1.5		7		2.2	0.314	0	0	発明鋼		
D11	40	0.3	0.15		0.425	Mo:0.01, Ti:0.02	無し	無し	670	31	89.3	0	8.2	1.5		7		2.2	0.314	0	0	発明鋼		
D11	41	0.25	0.1		0.425	Co:0.2, B:0.005	無し	微小	670	31	89.3	0	8.2	1.5		7		2.2	0.314	0.1	0	発明鋼		
D12	42	0.05	0.02	11	2.167	Y:0.01	有り	無し	620	37	88.5	7.5	0	4		8.5	2.5		0.294	0	0	発明鋼		
D12	43	0.1	0.01	11	1.417	Mo:0.02, K:0.02	有り	無し	620	37	88.5	7.5	0	4		8.5	2.5		0.294	0	0	発明鋼		
C1	44	0.4	0.8	10	5.81		有り	微小	775	22	77	0	0	23	***	3.4				75	比較鋼			
C2	45	0.04	0.5		7.23		無し	微小	985		主相はフェライトとベイナイトの混合*											比較鋼		
C3	46	0.01	0.01				無し	めっき 漏れず														比較鋼		
C4	47	0.01	0.01	12	2.75		有り	無し	895		主相はフェライトとベイナイトの混合*											比較鋼		
C5	48	0.01	0.01				有り	めっき 漏れず														比較鋼		

表中の下欄は本発明の範囲外の条件。

*主相がフェライトとベイナイトの場合において相の定量的測定が困難である。一方では、破断伸びが20%以下と低延性であり、高加工後のめっき密着性の評価が不可能である。

**合金化元素のない場合にはめっき相中にFeはほとんどみくまれない。

***各層の体積分率の合計100%となるが、炭化物、酸化物、窒化物および硫化物等の元素微量レベルでは微量的な相については主相の体積率に加えた。

[0075]

[Table 4]

表3 製造条件と高加工後のめっき密着性

鋼種	No	焼鈍条件: °C×分	1次冷却 速度: °C/s	1次冷却 停止温 度: °C	2次冷却 速度: °C/s	2次冷却 停止温 度: °C	めっき処理を含めた 停留条件	合金化 処理温 度:°C	合金化 処理時 間:秒	20%引張り加工後の 60° 曲げ-曲げ戻し後の めっき剥離率/%	
D1	1	800°C×3分	1	680	10	485	485~480°Cで18s	515	25	0	0 発明鋼
D1	2	800°C×3分	1	680	10	485	485~480°Cで23s	無し	無し	0.1	0 発明鋼
D1	3	800°C×3分	1	680		485	485~480°Cで23s	無し	無し	12	比較鋼
D1	4	800°C×3分	1	680	10	485	485~480°Cで18s		25	4	比較鋼
D2	5	800°C×3分	1	680	10	470	470~480°Cで15s	520	25	0	0 発明鋼
D2	12	800°C×3分	1	680	10	470	470~480°Cで25s	無し	無し	0.1	0 発明鋼
D3	13	810°C×3分	1	680	5	470	470~480°Cで18s	510	25	0~0.1	0 発明鋼
D3	20	810°C×3分	1	680	5	470	470~480°Cで33s	無し	無し	0.2	0 発明鋼
D3	21	810°C×3分	1	680	5	470	470~480°Cで25s	510	25	46	比較鋼
D4	22	830°C×3分	0.5	680	3	475	475~480°Cで20s	515	25	0	0 発明鋼
D5	23	830°C×3分	0.5	680	7	475	475~480°Cで5s	520	25	0.3	0 発明鋼
D6	24	830°C×3分	0.3	660	8	480	480~480°Cで20s	520	25	0~0.5	0 発明鋼
D7	32	800°C×3分	1	680	10	470	470~480°Cで25s	520	25	0.4	0 発明鋼
D7	33			680	70	470	470~480°Cで25s	無し	無し	20%引張り加工不可	比較鋼
D8	34	860°C×3分	1	680	10	480	480~480°Cで5s	無し	無し	0.5	0 発明鋼
D9	35	860°C×3分	0.5	650	3	480	480~480°Cで5s	無し	無し	0.7	0 発明鋼
D10	36	840°C×3分	1	680	10	480	480°Cで20s	510	25	0	0 発明鋼
D11	39	850°C×3分	1	680	30	480	480°Cで5s	無し	無し	0	0 発明鋼
D12	42	830°C×3分	1	680	10	480	460°Cで20s	510	25	0~0.1	0 発明鋼
C1	44	850°C×3分	5	680	30	470	470~480°Cで15s	510	25	20%引張り加工不可	比較鋼
C2	45	850°C×3分	1	690	10	470	470~480°Cで5s	無し	無し	20%引張り加工不可	比較鋼
C3	46	1000°C×3分	5	680	10	470	470~480°Cで15s	無し	無し	引張り試験前にめっき	比較鋼
C4	47	850°C×3分	5	680	30	470	470~480°Cで15s	510	25	20%引張り加工不可	比較鋼
C5	48	950°C×3分	1	680	30	470	470~480°Cで15s	510	25	引張り試験前にめっき	比較鋼

表中の下欄は本発明の範囲外の条件。

1次冷却速度: 焼鈍後、850~700°Cまでの冷却速度

2次冷却速度: 650~700°Cからめっき浴温度~めっき浴温度+100(°C)までの冷却速度

[0076]

[Effect of the Invention] By this invention, the outstanding high intensity hot-dip zinc-coated carbon steel sheet of the ductility which has improved the plating adhesion at the time of un-galvanizing or high processing can be obtained.

[Translation done.]